

explore impact of modality of boost radiotherapy (electron vs. HDR interstitial brachytherapy) on long term cosmesis.

Material and Methods: 194 early breast cancer patients (T1N0, T2N0, T1N1) underwent BCS (Lumpectomy =125, Quadrantectomy = 69) + N3 nodal dissection in our unit between July 2004 and March 2010 after metastatic work up. Clips (4 or 5) were placed in all for subsequent delineation of radiotherapy target. Receptor status (including Her 2 neu) was detected for all. All patients received post BCS adjuvant chemotherapy - FEC for 'low risk' cases and EC X 4 then taxane X 4 for 'intermediate' and 'high risk' cases. Whole breast radiotherapy was given to all (50 Gy/ 25 fractions with CT-based planning). 145/194 patients also received boost - either 15 Gy/ 6 fractions electron or 10 Gy/ single fraction HDR interstitial implant (2 or 3-planes) with individualized CT-based planning and geometrical optimization. DVH was analyzed in each for D90, Coverage index, Dose received by skin, DNR and COIN. Cosmetic outcome was analyzed in each follow up visit using 4-point scale (excellent, good, fair, poor).

Results: Out of evaluable 173/ 194 patients (4 died of metastasis, 17 lost to follow up) with minimum duration of follow up of 36 months, 86 did receive electron boost and 38 received HDR. Local recurrence was in none so far. The PTV differed significantly - median 38 cc with HDR vs. median 90 cc with electron. Cosmetic outcome was significantly different - only 48/86 patients receiving electron boost have 'excellent and good' cosmesis compared to 31/38 receiving HDR brachytherapy (P = 0.008). Grade 1-2 fibrosis was seen in 39/86 (46%) with electron and 6/38 with brachytherapy (P= 0.002). Grade 1-2 telangiectasia was also significantly lower with HDR brachy 3/38 vs 29/86 with electron (P= 0.0019). Arm oedema was negligible in all patients - only 2.8%.

Conclusion: For best cosmetic outcome after BCS, HDR brachytherapy (with CT-based 3D planning) for patients requiring boost radiotherapy appears to be much better option compared to electron unless the tumour is very superficial.

OC-0356

Long terms results of permanent breast seed implants (PBSI) as partial breast irradiation

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Purpose or Objective: Since 2004 breast cancer patients have been prospectively included in three clinical trials using post-operative permanent breast seed implant (PBSI) brachytherapy. We report the long term efficacy results of the technique on patients with low risk, small (less than 3 cm) and node negative tumors.

Material and Methods: The first trial was a Phase I/II accruing patient with low risk infiltrating ductal carcinoma (IDC), the second trial was a Phase II trial DCIS patients, and the third trial was a Multicentre Registry. All patients received PBSI delivering a dose of 90 Gy after CT-simulation and planning. Stranded ¹⁰³Pd seeds were implanted using light sedation, ultra-sound guidance, fiducial needle localization, and using template. Patients were followed-up annually for 10 years. Overall survival, disease free survival, local recurrence and ipsilateral recurrence at 5 years were compared to theoretical ones calculated using the IDC Tuft University IBTR and DCIS Memorial Sloan Kettering Cancer Center nomograms.

Results: From April 2004 to May 2014, a total of 134 patients have been accrued. The median FU of the entire series is 58.6 months [range 1.3 to 121.8 months]. The median age at surgery was 61.9 years old [41 to 84.5], 91% of patients had an invasive tumor and the remaining were DCIS. All patients were T1-2 N0, grade 1 or 2 but one was found node positive on pathology review. At time of evaluation 119 patients were without any evidence of disease. The local recurrence free survival at 5 years was 98.8% (SD ± 1.20%), which was not statistically significantly different to the theoretical rate of 98.6% for patients receiving whole breast radiotherapy (p=0.23). But this rate was significantly better than the 95.4% theoretical risk of local recurrence with surgery alone (RR=0.27, p<0.001). The 5 year overall survival was 97.4% (SD ± 1.91%) and the disease free survival was 96.4% (SD ± 2.07%). In terms of tolerance, 22% of patients had telangiectasia almost exclusively grade I at 2 years. This rate decreases over time to 16% at 8 years. Of note 40% of the patients developed a palpable and asymptomatic induration in the surgical scar.

Conclusion: Long-term results suggest that PBSI is a well-tolerated treatment, with an efficacy similar to whole breast radiotherapy for well-selected early stage breast patients. This treatment represents a good treatment option for patients having difficulties attending prolonged radiotherapy protocols.

Proffered Papers: Physics 8: Dose measurement and dose calculation I

OC-0357

Pilot study of a remote end-to-end dosimetry audit for IMRT and VMAT treatments

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Purpose or Objective: The new methodology for end-to-end remote dosimetric quality audit for IMRT and VMAT treatments for national dosimetry audit networks has been developed within a co-ordinated research project (CRP). The purpose of this audit is to verify the entire radiotherapy chain including imaging, treatment planning and dose delivery for a clinical IMRT treatment executed with either a static or rotating gantry. Overall 16 research groups from 13 countries participate in this CRP. Results of a pilot study involving 6 CRP participants are presented.

Material and Methods: A polystyrene phantom (see Fig. 1) was designed for this exercise with the solid water structures representing PTV and OAR. Each participant received a phantom preloaded with a custom cut EBT3 film and 4 TLDs (2 in PTV and 2 in OAR), extra TLDs for imaging and a set of instructions and datasheets. Participants were asked to scan the phantom, contour the structures, create the treatment plan and irradiate the phantom. The plan was generated as for a patient to deliver 4 Gy to PTV in 2 fractions and limit

the dose to OAR to 2.8 Gy (additional target objectives were provided).

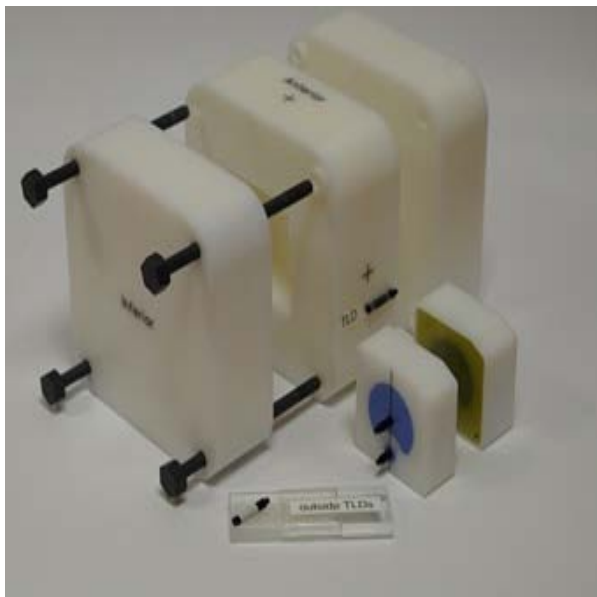


Fig. 1 IMRT phantom with an insert loaded with film and TLDs.

Upon receipt of the irradiated phantom by the CRP organiser, TLDs and film were evaluated. Comparison was performed between the calculated and the film measured dose distributions using a gamma analysis tool (FilmQA ProTM, Ashland). The gamma acceptance criterion of 3%/3 mm over all pixel values exceeding 20% of the maximum dose was adopted. TLD results were presented as ratios of the TLD measured dose and the participant stated dose, $D(TLD)/D(stat)$.

Results: The results were obtained for 6 participants using 6 different accelerator models, 4 MLC models, 3 TPS models and 5 dose calculation algorithms. All participants created treatment plans which fulfilled the dose constraints provided. The results of gamma evaluation were between 93.5% and 100%. TLD results for PTV showed good agreement with the average $D(TLD)/D(stat) = 0.995$ and 1.2 % standard deviation (SD), whereas for OAR the average $D(TLD)/D(stat)$ was 1.041 and the SD = 4.6%. As OAR was located in a high dose gradient region, even a 1 mm positional shift could cause significant TLD dose difference.

Conclusion: The methodology of this audit, examined through a pilot study, proved to work well. The instructions and datasheets appeared to be clear and straightforward to follow. The results showed good agreement for TLDs in PTV and also between the planned and the film measured dose distributions. However, TLD measurements in the OAR were challenging because of the high dose gradient in this region. The results of the pilot study were used to assess the measurement uncertainties and will help in establishing the acceptance limits for audit results. The study continues with 10 additional research groups involved in the CRP.

OC-0358

Surface doses with FFF VMAT dose delivery for breast cancer

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Purpose or Objective: Flattening filter free (FFF) beams have the potential to speed up breast cancer radiotherapy (RT) treatments and reduce whole body dose of a patient by reducing treatment head leakage. However, the near surface

dose data of modulated FFF beams is lacking. In this work the surface doses were studied with various treatment plans for breast cancer RT with both FFF and flattening filter (FF) beams.

Material and Methods: This study was executed with EBT3 films irradiated in a cylindrical phantom (CIRS, Ø16cm). The phantom was imaged with CT scanner (slice width 1 mm). PTV and critical organs were contoured to the 3D images (Fig.1). Four clinical treatment plans (photon energy 6 MV, fractional dose 2 Gy) were created for Elekta Infinity accelerator with Agility MLC: 1) tangential open field, 2) tangential IMRT with dynamic MLC (DMLC), 3) tangential VMAT (tVMAT) and 4) continuous VMAT (cVMAT) (Fig.1). Doses were calculated to water with X-ray Voxel Monte Carlo algorithm (XVMC, Monaco v5.00.04, Elekta) with a resolution of 1 mm and STD of 0.5%. Treatment plans were normalized to mean dose of PTV. All irradiations were repeated three times and the calibrated films were scanned in RGB mode. Red channel data was used in analysis with OmniProlMRT software (v1.7, IBA, Germany).

Results: Calculated and measured surface dose distributions were compared and are presented for FFF in Fig.1. The overall accuracy of XVMC calculation was good with the largest point dose difference of -11% recorded with FFF DMLC. Line dose analysis was performed in lateral and central parts of the phantom to evaluate surface doses with respect to beam directions (shown in Fig.1). Compared with measured dose the calculated doses were on average 3% larger at the depths of 0-2 mm (relevant depth for RT induced skin reactions). At 2-5 mm depths the dose deviation was on average 0% (Table 1). Central part surface doses at 0-2 mm were on average 27% higher with open fields than with both VMAT techniques which was also well predicted by the TPS (max error 4%). Within the lateral parts the average surface doses between the techniques deviated less than 8% (range 45% - 48%). An important finding was also that on average the lowest values of surface doses were measured with open fields (lateral parts). No significant differences in surface doses were detected between FFF and FF techniques.

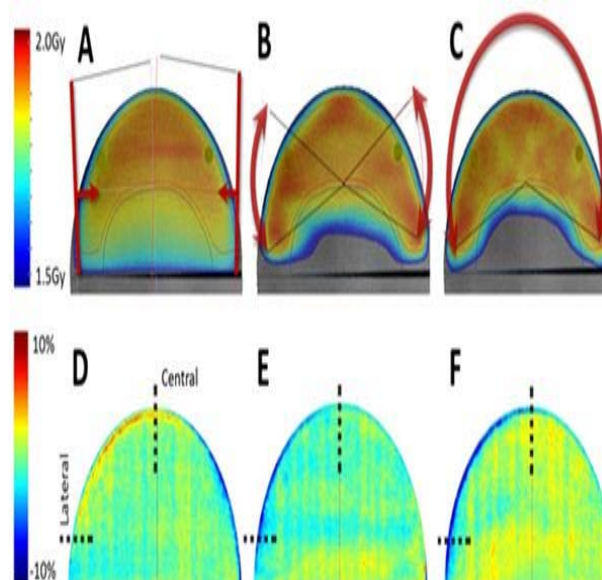


Fig.1: Calculated dose distributions of (A) open field, (B) tVMAT and (C) cVMAT treatment plans with FFF and the corresponding differences against the measured dose distributions (meas-calc) in D, E and F, respectively.

Table 1: Measured and calculated surface doses of FFF and FF (depths of 0-2mm and 2-5mm).